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The growth rate of fish depend on the amount of food available and its nutritive value. In addition, different fish feed on different food. For instance, grass carp feed on various terrestrial and aquatic plants; white bighead feed on phytoplankton; and striped bighead feed on zooplankton. Generally fish are grouped as either herbivores, carnivores or omnivores. However, during young stages, most fish eat plankton.

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Natural fish food is generally comprised of phytoplankton, zooplankton, benthic animals, aquatic plants, and dead animals and attached bacteria.

The type and quantity of natural fish food fluctuates seasonally and varies according to the type of water body.

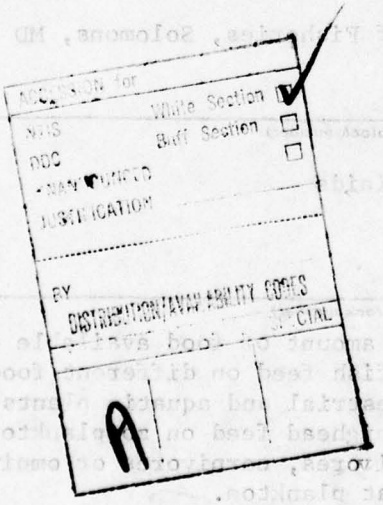
Physical, chemical and biological factors also affect the growth and development of organisms in a body of water. Physical factors vary seasonally and according to the geography and, in turn, affect the chemical and biological factors.

The major physical factors are temperature, water current and light. The major chemical factors are organic matter, dissolved inorganic salts, dissolved gases and pH. The biological factors refer to the interrelationships among species.

The vegetative food often used in rearing fish in China are: farm products, such as soybean milk; byproducts and waste material of the food industry, such as bean cake, grain residue, rice bran, wheat husk, etc; aquatic and terrestrial plants which can be used either directly as food (as for grass carp) or indirectly as fertilizer to culture plankton; animal and human manure; and food substitutes, such as decaying plants and bottom mud.

Snails, yellow clams, oval mussels, fly maggots, grasshoppers, earthworms, Daphnia, silkworm pupae, and fish meal are also used as fish food.

In addition to abundance, a good fish food must contain proteins, carbohydrates, fats, inorganic salts and vitamins. Therefore, mixed fish food is used to optimize nutritional value.



Chapter 7

NATURAL FOOD OF FRESH WATER FISHES

Introduction

The growth rate and fatness of fish depend upon the amount of food available and its nutritive value. Different fishes feed on different foods. For instance, grass carp feed on various aquatic and terrestrial plants; black Chine roach feed on snails; white bighead feed on phytoplankton; striped bighead feed on zooplankton; and carp and goldfish are omnivorous. Generally fish can be grouped into carnivores, herbivores, and omnivores. However, during young stages, most fish feed on plankton.

In fish culture, food is provided either by directly feeding or by enriching the water so as to promote planktonic growth. For grass carp and black Chinese roach, the first method is used; for the bigheads, the second method is used.

In the past some researchers maintained that because cyprinids lack fibre-digesting enzymes, their ability of utilizing plant material is limited or nil. However, other researchers demonstrated that these fish can obtain such enzymes through animal food they ingested and depended upon these exogenic enzymes to digest fibrous food.

Principal composition of natural food

Natural fish food comprises the following kinds:

Phytoplankton - diatoms and many unicellular algae.

Zooplankton - including protozoa, rotifers, daphnids, copepods, and some molluscan larvae.

Benthic animals - including aquatic oligochaetes, nematodes, molluscs, aquatic insect larvae, etc.

Aquatic plants - mainly vascular plants, Potamogeton, Vallisneria, etc.

Dead animal bodies and attached bacteria - organic matter can serve as food for benthic species of fish.

Species composition of fish food varies according to the kind of water body.

1. Natural food in rivers. In the upper section of the river where the current is rapid and dissolved oxygen is rich, there are many kinds of algae, such as Cladophora, Gomphonema, Navicula, Cocconeis, etc. Also present are large numbers of insect larvae, such as plecoptera, ephemerida, odonata, etc. Planktonic organisms are rare.

In the lower section of the river where the current is slow, plankton greatly increases in species and quantity. Phytoplankton include Cyclotella, Melosira, Nitzshia, Achnanthes, Cymbella, etc., and a variety of algae, such as Chlamydomonas, Scenedesmus, Ankistrodesmus, Chroococcus, Chroomonas, Eurorina, Pandorina, and Volvox.

Zooplankton also greatly increases in the lower section of the river. The more commonly seen species are: Difflugia, Arcella, Acanthocystis, Coleps, Tintinnidium, Strobilidium,

Strombidium, Epistylis, Halteria, Stentor, Asplanchna, Polyarthra, Synchaeta, Conochilus, Cephalodella, Diurella, Lecane, Truchicerca, Colurella, Brachionus, Schizocerca, Pedalia, Daphnia, Bosmina, Alona, Sida, Chydorua, Bosminopsis, Ceriodaphnia, Simocephalus, and many others.

Also increased in number are benthic animals. The principal ones include chiromonids and oligochaetes. Others like Ephemerida, plecoptera, Trichoptera, Hemiptera, Coleoptera are also abundant, Mollusca include both gastropods and polecypods.

Aquatic vascular plants grow only in shallower parts of the river where current flow is slow.

2. Natural food in lakes. Fish food is much richer in the lakes than in rivers. There are numerous kinds of phytoplankton. Most important are many species of diatoms, green algae, and blue algae.

Zooplankton species are also abundant. Many species of protozoans, rotifers, water fleas, and copepods are present.

Benthic animals are mainly consisted of chironomid larvae, anaelids, and snails. In lakes along lower Yangtze River, pelecypods are sometimes abundant; more than ten species may be present.

There are many kinds of aquatic vascular plants. The principal ones are Phragmitis communis, Zizania latifolia, Trapa incisa var. quadricaudata, Limnanthemum nymphoides Hydrocharis asiaticus, Myriophyllum spicatum, Najas, etc.

These plants generally occur in shallow water along lake shores. In some lakes Chara is very thick.

3. Natural food in reservoirs. Species composition of fish food in reservoirs is intermidiate between that in rivers and that in lakes. Most medium sized to large sized reservoirs are built from rivers by damming. Therefore at the beginning, the fauna in the new reservoir is the same as in the original river. But as the ecology gradually changes to that similar to lakes, lake type organisms also begin to appear.

4. Natural food in ponds. Food species in ponds are those that prefer organic nutrients. Abundantly present are phytoplankton (algae) and protozoans, many species of rotifers, and daphnias and copepods.

Because physio-chemical conditions are easily altered by adding food and fertilizers, faunal make-up also changes accordingly.

Fluctuations in natural food

The number and quantity of natural food species fluctuate seasonally and vary according to the type of water body.

In rivers which freeze in winter, seasonal changes of water conditions are very distinct. During the spring thaw, volume of flow increases rapidly and the temperature is also rising. This accelerates growth of organisms. The thaw of snow and ice brings forth a large quantity of organic

material and minerals, thus enriching the river water tremendously. As a consequence, plankton and benthic animals flourish. Diatom population often reaches peak during the spring. In Heilung River, for instance, river ice breaks up in mid-May, and by mid-June phytoplankton reaches its first peak. Each liter of water contains 1,970,000 cells, of which diatoms account for 50.9%; benthic animals also reach a peak at the end of June.

With the continuous outflow of water from the river, the level of nutrient material gradually decreases, and plankton is also reduced, although benthic animals and aquatic plants keep on increasing in quantity.

During water level rise in the fall, plankton is again on the rise, and benthic animals and aquatic plants reach maximum development. Producibility lowers when freezing sets in toward the end of autumn.

In non-freezing rivers, the main source of water supply is rain. Scouring after raining will bring mud into the river and increase turbidity, thereby reduce light penetration and retard growth of organisms.

In large rivers where water level changes are great, turbidity is high, and the river is deep, aquatic high plants are relatively rare. In small rivers, plants are plentiful, especially during summer to autumn.

In lakes where the water level is relatively stable and flow rather small, the growth and development of food species

are quite normal and regular. Most of the lakes in China are relatively shallow and rich in nutrients. Plankton, benthic animals, and higher aquatic plants are all abundant.

Phytoplankton is at its peak during the spring, levels off in summer and autumn, and at the minimum in the winter.

Seasonal fluctuations of zooplankton in the lakes are not as sharply defined as phytoplankton. Generally, they are more abundant in spring and summer and less abundant in autumn and winter. Protozoans increase greatly in quantity during the spring, decrease in summer, increase again in the fall, and drop off in winter. But protozoans are seldom used directly as fish food. More important food species are rotifers, daphnias, and copepods. Rotifers are abundant in spring, reduce in summer, increase in fall, and diminish again in winter. Daphnias are more abundant from spring to autumn, but less abundant in winter. Copepods are present during all seasons, but are more abundant in fall and winter.

Chironomids constitute a major part of benthic fauna. They appear in great quantities in spring, summer, and fall. Molluscs are also abundant in lakes. Benthic animals are generally distributed along lake shores where the water is shallow, but they are distributed all over the lake in shallow lakes. In a Hupeh lake, there is an average of 36 pounds of benthic animals per acre of lake surface.

When aquatic plants are thick in a lake, benthic animals are usually plentiful, but planktonic organisms are less

abundant. Under these conditions, the lake is very clear and rich in dissolved oxygen. On the other hand, during a phytoplankton bloom, light penetration is limited, which retards the growth of bottom plants.

The status of zooplankton and phytoplankton in a reservoir is similar to that of an open lake. On the other hand, the reservoir has the characteristics of a lake; on the other, it also has spring and autumn flood, which is similar to a river. Due to continuing sedimentation of sand and mud, both quantity and number of species are relatively limited.

Factors affecting natural food

The growth and development of organisms in a lake may be affected by physical, chemical, and biological factors. Physical factors vary seasonally and according to geographical areas. Chemical and biological factors are affected by physical factors.

Major physical factors are temperature, light, and current velocity. Major chemical factors are dissolved inorganic salts, organic matter, gas, and pH. Biological factors refer to interrelationships and competition among species.

The interrelationships among species have already been discussed. The following is a brief discussion of temperature, light, dissolved inorganic salts, and organic matter and their effects on aquatic organisms.

1. Temperature. To the growth and development of life, temperature is an important factor. Under very low temperatures, vital activity reduces and may even cause death. Gradually increasing temperatures usually increase metabolic rate. In general, for each increase of 10 C, the metabolic rate is doubled or tripled. Too high temperature, however, may also cause death.

Some species are adapted to a wide amplitude of temperature fluctuations; they are eurythermal. Others are stenothermal; i.e., those that can live within a narrow range of temperature regime. The eurythermal species can grow within wider latitudes. They can grow in tropics, and can be found also in arctics. The stenothermal forms are more or less regional.

Because water is a slower heat conductor and is also slower in heat absorption and release, water temperature does not change as fast as air temperature. Many weak organisms can survive daily temperature differential. Also, because the body of organisms are immersed in the water, there can be no evaporation due to heat as in land organisms.

Temperature not only can directly affect the living processes but also can influence the dissociation and chemical processes of matter, thereby indirectly affecting the absorption and utilization of materials by organisms.

2. Light. Light is indispensable to plant growth. Its chief effect is related to movement and reproductive activity.

Green plants require ample light energy for photosynthesis. Light is the main source of productivity of both land and water organisms. The productivity of a water body is often determined by the condition of aquatic plants.

The main source of light is solar radiation. The duration and intensity of light is dependent upon latitude, altitude, and season.

In the northern hemisphere, the higher the latitude, the longer the sun shine in summer, and the shorter in winter. Sunshine affects temperature on each. Therefore, the air and water temperatures are directly proportional to the amount and intensity of sun light.

Water can absorb and radiate light, and this ability is increased when suspended or dissolved material is increased. At the same time, light penetration is reduced. Therefore deep water is not conducive to plant growth. This is why a deeper lake is not necessarily more productive.

Different plants demand different light intensity and quality. Some plants prefer strong light; others like weak light. Some prefer light of long wave length (red and orange); others like short wave length (green, blue). Therefore, it is not always at low latitude or summer time that plants grow at their best. For instance, planktonic green and blue algae like strong light and high temperature, but diatoms prefer weak light and low temperature. The distribution of aquatic plants in water is affected and limited by sun light.

Light has an important bearing on the movement of zoo-plankton and benthic animals. For example, the diurnal migration of zooplankton is closely related to light. Many animals have distinctive positive or negative phototropism. Light is therefore an important factor that affects the distribution of aquatic animals.

3. Dissolved inorganic salts and organic matter. All natural water bodies contain inorganic salts. Inland waters can be classified into four categories according to their salt content. (1) Freshwater, containing 0.5% salt; (2) saline water, containing 0.5-2.5% salt; (3) supersaline containing 25-100% salt; (4) hypersaline, containing 100-300% salt.

The amount of salt content in water affects osmotic pressure of living cells.

Many organisms can tolerate a wide fluctuation of salinity; they can survive in both freshwater and salt water. These are called euryhaline forms. Others are adapted to a narrow amplitude of salinity fluctuation. These are called stenhaline forms. Species composition is quite different in freshwater and salt water lakes. Even different freshwaters contain varying amounts of calcium, which can also affect species distribution.

In freshwater, the more important salts that affect the abundance of organisms are nitrates and phosphates. Nitrogen is an indispensable ingredient for building plant protein and phosphorus provides raw material for nuclear plasm. The

amount of these salts in water are often the important factors that control the growth of plants. Some workers classify lakes into eutrophic or oligotrophic according to contents of nitrates and phosphates. Eutrophic if nitrogen is over 0.2 ml per 1, and phosphorus is over 0.02 ml per 1; lower than this level, the lake is considered oligotrophic. Other criteria must also be considered, for when large amounts of nitrogen and phosphorus are used in active metabolism, lake contents of these elements are drastically reduced even though the lake is eutrophic.

Aside from the above salts and elements, potassium, magnesium, iron, and manganese are also important in affecting the distribution of plants.

The organic matter that is contained in water is often an important factor affecting the breeding of zooplankton, especially protozoans, rotifers, and daphnias. Therefore, the amount of organic matter can be used as an index of productivity of the water body. Of course, if the content of organic matter becomes too high, it can deplete oxygen, and seriously deteriorate the water quality (as producing large amounts of hydrogen sulphide and marsh gas) and depress growth or cause mass mortality among organisms.

Phytoplankton releases a large amount of oxygen as a result of photosynthesis. This helps to split up organic matter into simpler materials or salts that can be readily available to organisms. Therefore, the introduction of sewage into fish ponds, if it can be controlled, can often

fertilize the water, which increases fish food and promotes fish growth.

Food for freshwater fishes

1. Vegetative food. In the past only in rearing grass carp was fresh aquatic or terrestrial plants used as food in China. Today five kinds of vegative foods are used.

(1) Farm products. The main item used is soybean. It is used in the form of soybean milk to feed fry. Milk is prepared by grinding well soaked soybean with water and by filtering out solids. The function of soybean is probably two-fold. One is as direct food for fish, and the other is to promote plankton growth, which in turn is used by fish as food.

In South China, to rear fish fry, hay is placed in fish pond to culture plankton. It is as effective as soybean milk.

In recent years, the byproduct of soybean oil has been used to produce milk. First, soybean is pressed to produce oil. Then the soybean cake is soaked and ground to produce milk. It is as good as soybean milk itself. In one rearing station, only 13 pounds of soybean cake was used to rear 10,000 fry (about an inch long) for 20 days.

(2) Byproduct and waste material of food industry.

i. Bean cake. To feed adult fish, cut the bean cake into small pieces. To feed fry, smash the cake into paste form.

ii. Bean residue. This is residue that resulted from soybean milk preparation. It can be used to feed both fry and adult fish.

iii. Grain residue from wine and liquor preparation. This is a fine food for both adult and fry. It may be made of corn, wheat, barley, or sorghum.

iv. Rice bran, wheat husk. These are used mainly to feed fish fry, but can be used also to feed adult fish. To feed fry, they must be mixed with water and ground into fine particles.

v. Residue from soy sauce preparation. This residue contains salt and therefore must be mixed with other food in feeding fish. In mixing, it should not exceed 1%.

vi. Cabbage seed cake. After oil is pressed out of cabbage seeds, the residue forms a cake. Use in the same manner as the bean cake. It is very very good for both fry and adult fish.

vii. Cotton seed cake. This is the residue of cotton seeds after oil is pressed out. It is as good as bean cake, but costs only half as much. In USSR, it is used as the main food item for carp. In Chekiang, it is mixed with other food for feeding purpose.

(3) Aquatic and terrestrial plants. Plants can be used either directly as food (as for grass carp) or indirectly as fertilizer which cultures plankton.

Many kinds of plants can be used to feed grass carp. Among aquatic plants are: Wolffia arrhiza, Lemna minor,

Spirodela polyrhiza, Vallisneria spiralis, Potamogeton malainus, P. maackianus, P. crispus, Hydrilla verticillata, Najas minor, etc.

Among terrestrial plants are: Echinochloa crus-galli, Setaria viridis, Pennisetum alopecuroides, Eleusine indica: also stems, leaves, and seeds of legumes; Lactuca sativa, and Taraxacum officinale of Compositae; and waste leaves of a variety of green vegetables.

In recent years, many other plants have been introduced as fish food; such as Alternanthera philoxeroides, Ipomoea reptans, Eichhornia crassipes, Pistia stratiotes, etc. Even leaves of many kinds of trees are used. For example: pine, willow, tung, etc.

The culturing methods of some of the aquatic plants are described below:

i. Wolffia arrhiza

(i) Selection of Wolffia pond: Wolffia prefers still water. Therefore, the pond should be on the lee side. Pond should be small, not over 1/6 of an acre and not more than 4-5 feet deep.

(ii) Wolffia does not have to be reseeded every year in a pond in which Wolffia has been grown for two years. Otherwise 15 or so pounds of seed Wolffia should be planted for every 1/6 acre. The growth rate of Wolffia is very closely related to temperature. Under 27 C, growth is most rapid; temperature lower than 20 C or higher than 35 C will retard growth.

(iii) Pond cleaning and fertilization. Wolffia pond should be started in late March. It is first drained, then treated with lime to kill off wild fish. Finally it should be fertilized with lamb manure. Manure of other animals or humans can be used also but not as good.

(iv) Harvest of Wolffia. Wolffia can be harvested either in the morning or in the afternoon with a net. Each time the take should not be over 60% of the plant present in the pond. On the average, about 3,000 pounds can be taken out of an acre of pond every two days. It can be harvested from April to September in eastern China.

(v) Follow up fertilization and management of Wolffia pond. It is best to fertilize Wolffia pond every day. To each acre about 400 pounds of night soil can be added. During the summer Wolffia should be sprayed with water from the surface to avoid dryness. During the entire growing season, wild plants and frog eggs should be removed constantly.

(vi) Transplantation. Wolffia can be transplanted easily by transporting it in a closed container. The best time for transplantation is between March and May when air temperature is relatively low.

(vii) Wolffia disease and control. Iron rust, which is caused by certain algae, can be controlled by adding diluted night soil. Another disease, caused by certain green algae, can be controlled by adding 2 ppm of copper sulphate.

ii. Spirodela polyrhiza. The culture method of this plant is similar to that of Wolffia.

iii. Alternanthera philoxeroides, Pistia stratiotes, Eichornia crassipes are also cultured for the purpose of feeding fish. The method of culturing is similar to that of culturing Wolffia.

Byproduct of farm product. Many agricultural byproducts can also be utilized to feed fish. The commonly used ones are green rice hay, squash leaves, potato stems and leaves, peanut plants and peanut shells. Other farm products that are used as raw materials in mixing with other food stuffs to feed fish include corn stems and leaves; stems, leaves, and shells of broadbeans; cabbage; rice husks; etc.

(4) Animal and human manure. Aside from being used as a fertilizer, manure can also be used as fish food. Manure of man, cattle, and pig can be mixed with other material and used directly to feed fish.

Fecal deposits of silkworm have been used by Chekiang fishermen to feed grass carp and black Chinese roach.

(5) Food substitutes. Decaying aquatic plants and bottom mud are often used to mix with other food to feed fish.

2. The nutritional ingredients of plant food. Aside from containing protein, carbohydrate, fat, inorganic salts, and vitamins, plant food also has a large amount of cellulose, which cannot be digested very well by cyprinids. In evaluating the food quality, therefore, both the protein

and cellulose contents should be measured. The higher the protein and the lower the cellulose contents, the better is the quality of the food.

The chemical composition of a food material is not the only criterion that should be based for an evaluation of the quality of food. The digestibility of the various ingredients must also be considered. For instance, corn contains 6.2% of protein, or 6.1% digestible protein; soy sauce residue contains 13.4% protein but only 9.8% digestible protein. Therefore, in comparing the nutritional value of corn and soy sauce residue, the ratio is not 6.2 to 13.4, but rather 6.1 to 9.8.

Vitamins and inorganic salts are also important ingredients that should be weighed in evaluating the food.

The chemical composition of the commonly used fish foods is listed in Table 12.

Table 12. Chemical composition of fish foods. (p. 155-156)

Name of food	Water %	Dry material	Protein %	Fat %	Cellulose %	Non-nitrogenous extract, %
			Ash, % Determined by			

3. Processing of fish food. The principal purposes of processing plants for fish food are (1) to facilitate ingestion by the fish, such as grinding the bean cake into fine pieces;

(2) to upgrade the nutritional value and utilization rate, such as softening and fermentation; (3) to facilitate preservation and storage; and (4) to improve the flavor.

There are generally three means of processing: mechanical, chemical, and biological.

(1) Mechanical method. this includes soaking, cutting, grinding, mixing, etc.

(2) Chemical method. this includes heating and soaking in hot water to remove some of the soluble salts and alkali, treating with acids or bases to hydrolyze cellulose into sugars.

(3) Biological method. the principal method is via fermentation by microorganisms. This is the simplest, most effective, and cheapest method. the bacteria convert cellulose and protein into sugars and amino acids on the one hand, and supply a large amount of digestive enzymes and vitamins on the other.

There are various ways of biological processing. The two methods which are currently adopted are as follows:

i. Green storage and fermentation. Various kinds of nontoxic plants can be used. They should be cut before blooming. The green foliage and stem are cut into 4-8 cm pieces and compacted into a container and tightly sealed to prevent air and water from getting in. Fermentation process can be completed in 25 days for grass and 7-10 days for vegetables at a temperature of 20 C.

ii. Rice hay powder. Add special enzymes to pulverized hay. The hay will be converted into powder form. this is an excellent feed for hogs. Its application to fish has yet to be tried, however.

Animal food

1. Snails, Viviparus (Idiopoma) quadratus (Bensen). These snails abound in rivers, creeks, and lakes. They are the favorite food of black Chinese roach. they can be collected with either a square net and a bamboo scraper (a bamboo cylinder cut in half) or a push net.

2. Yellow clam, Corbicula fluminea (Muller). Yellow clam is also called river clam or pea clam. It grows in river or lake mud, and is usually collected together with snails. It is a very good food for the fry of black Chinese roach.

3. Oval mussel, Anodonta arcaeformis (Heude). This is a widely distributed species and is usually collected together with the snails. There are also a variety of other species of mussels which can be collected, but they occur in smaller quantity. When small, the mussels can be fed directly to fish; when large, they must be smashed before using.

4. Mud snail, Bullacta exarata (Philippi). This is a marine species, quite abundant during low tides. As a fish food, it is not inferior to silkworm pupae.

5. Fly maggots. Fly maggots are a very good fish food. They contain 55% protein, 28% fat, 7% carbohydrate, and

10% ash. Many fly species provide larvae which are suitable for fish food. These include Sarcophaga spp., Musca domestica, Lucilia sericata, Calliphora grahami, etc.

6. Grasshopper. Collecting grasshopper nymphs as a fish food serves a dual purpose in eliminating an agricultural pest on the one hand and providing a new source of fish food on the other. The only problem is that it cannot be relied upon as a regular food.

7. Earthworm. There are over 120 species of earthworm in China. They are easy to cultivate and are good fish food.

8. Daphnia. Daphnia is often used to feed aquarium fishes. It is cultured in large scale for commercial production.

9. Silkworm pupae. After silk is spun from cocoons, the pupae can be kept for fish food. The nutritional value of the pupae is very high, containing 17.1% protein and 9.2% fat.

10. Fish meal. This is produced from scrap fish and fishery byproduct and is used as a mixing agent for fish food.

Mixed fish food

1. Utilization of mixed fish food in China. Only since 1958 have people in China begun to experiment with mixed food to feed fish. The advantage of mixed food is that it can convert raw material that is normally not attractive to fish into a food that is liked by fish. For instance, Alternanthera philoxeroides is not normally taken by fish as food. But when it is cut into small pieces, cooked and smashed, and then mixed with rice bran, salt, and soda

powder to form a paste, it becomes a very good food which is readily consumed by all four domestic cyprinid species.

The Fisheries Research Institute in Chekiang Province has made available several mixing formulas which yield very good results:

Formula 1: Rice bran ----------50%
Wolffia arrhiza ------20%
Silkworm pupae -------20%
Snails ----------10%

Formula 2: Pine leaves ---------- 5%
Bean cake ----------10%
Silkworm pupae -------20%
Rice bran ----------30%
Wolffia arrhiza ------35%
Snails ---------- 1%

Formula 3: Cotton seed cake -----40%
Cabbage stem ---------20%
Hay powder ----------20%
Bran ----------20%
Snails ----------20%

2. Principles of food mixing. In mixing fish food, the nutritional requirements of fish must be met. A good fish food must contain protein, carbohydrate, fat, inorganic salts, and vitamins.

Protein is the principal ingredient of the animal body. The growth and reproduction of animals require protein. It

cannot be substituted with other food materials. A fish fed only with carbohydrate cannot maintain a protein balance; in fact it will lose more protein than a fish that is starved.

Food requirements which vary according to fishes are growth condition, and the season in which the food is fed. Generally, young fish require more protein than adults. In summer, protein content in fish food should be increased; in winter, carbohydrate and fat should be increased.

The protein content of a food is often expressed in a protein ratio, which is the ratio between protein content and the combined content of carbohydrate and fat. For example, plankton contains 61% protein, 11% fat, and 5% carbohydrate, which gives a protein ratio of 1:.25.

Some fishery workers in the Soviet Union maintain that for juvenile carp, the protein ratio should be 1:0.4-0.5; for 1-year old carp, 1:0.7-1.0; for 2-year old carp, 1:2 to 1:3; for 3-year old carp, 1:5. Of course, the proper protein ratio for each area must be worked out for the particular area. In USSR, by improving the nutrition of fish food, they are able to grow carp to 600-800g in one year, compared with the normal growth of 30-40g.

Inorganic salts in fish food also play an important role. They can enhance the utilization of carbohydrate by fish. Especially important are calcium, phosphorus, sodium, and nitrogen contents. Adding powdered bones and table salt to fish food helps to increase fishes appetite and promotes growth of muscular and bony tissues.

Vitamins play a special part in the normal growth of fish. For instance, vitamin B can help digestion and metabolism; vitamin C can also enhance metabolic activity; vitamin D is important to bone formation and the utilization of potassium and phosphorus.

3. Merits of mixed food. By utilizing mixed food, a vast source of raw material is opended up. By using various ingredients, it is possible to complement each other and prepare an ideal nutritious food. Finally, mass production becomes possible by mechanization.